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ABSTRACT

Prepared for a 1984 Organisation for Economic Cooperation and Development (OECD) conference, this report discusses the implications of the adoption of the new technologies for teacher functions and for the education and training of teachers. The developments taking place in the technologies themselves and the growing understanding of just how wide implications of the new information technologies might be for education are also considered as factors having an important bearing on teaching functions and teacher education. The role of primary education, the emergence of the new information technology coordinator, and teacher competencies are discussed in relation to the current state of affairs in response to the new information technologies; teacher competencies identified include basic machine understanding, management of hardware, software applications, and pedagogic use. Five areas of technological development--processing power of microcomputers, information storage, multimedia resources, software development, and communications technology--are identified and discussed in the context of changes in teacher function. Implications for teacher training--preservice structure and resources, research and development, and need for policy guidelines--are reviewed, and specific strategies for teacher education development are presented. A four-page bibliography concludes the document. (MBR)

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International Conference on Education and New Information Technologies

Château de la Muette
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NEW TEACHING FUNCTIONS AND IMPLICATIONS FOR NEW TRAINING PROGRAMMES

1. The attached document has been prepared by Rhys Gwyn, Principal Lecturer, Manchester Polytechnic, United Kingdom, in his capacity as consultant to the Secretariat. It will serve as a background report for Working Group 4.

2. The views expressed are those of the author and do not commit either the Organisation or the national authorities concerned.

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1. This report, prepared for the OECD/CERI Conference on Education and New Information Technologies pays specific attention to one of the sub-themes of the Conference, namely the implications of the adoption of the new technologies for teacher functions and for the education and training of teachers.

2. Given the extremely rapid evolution of educational responses to the NIT and the diversity of strategies being adopted, any such report must be, inevitably, both subjective and limited. The author therefore accepts full responsibility for any orientation to the report which is seen as partial or as a purely personal viewpoint -- indeed, the report is written in the belief that one of the problems to be faced is that currently, at national as well as institutional and individual levels, we are all operating on "personal" viewpoints. What is claimed here, in defence of the views expressed, is that they are at least based upon many years' experience of studying the education and training of teachers at the European level and also upon a number of years spent examining, again at European level, the impact of the new technologies on teacher training.

3. In this latter context, it is a pleasure to put on record the immense benefit gained from working, over a period of five years or so, with colleagues in the Information Technology Working Group of the Association for Teacher Education in Europe (ATEE). Debate within this group has never been less than lively, and has made it very clear that when we talk of inserting the NIT into our education systems and our educational practices, we have to remember that our systems and our practices do in fact differ quite widely one from the other. Even when considering the countries of Western Europe alone, we ignore at our peril the cultural differences between our various definitions of what it is to be educated. In the wider context of OECD membership, the caveat becomes even more important. Despite these differences, however, debate with colleagues in the ATEE group has been a constant stimulus to thinking and has, inevitably, left its mark on the observations put together here.

4. Another debt which it is a pleasure to acknowledge is to the colleagues who wrote the Country Reports upon which this paper has drawn so heavily. Their papers are a mine of information about the present situation in their respective countries, and without them, this synthesis report would have been

far more superficial and impressionistic than it is. The authors in question are (for France) M. Jean Valérien, (for the United Kingdom) Mr. Maurice Edmondson and (for the United States) Professors Robert D. Hess and Irene T. Miura of Stanford University, and Professor Nolan Estes, of the University of Texas at Austin. Two more reports were expected, but were not available by the time the present analysis was prepared. Possibly they will be included in a final version of this report.

5. These debts notwithstanding, it has to be said again that the views, omissions, errors and distortions found in this Report are the responsibility of the author and of the author alone.

INTRODUCTION

1. This report examines the impact of the new information technologies (NIT) on educational practices in OECD Member countries. It focusses especially upon the changes to which the new technologies point in the functions of the teacher, and also upon the implications of these changes for teacher training. As will become evident, however, it is not possible to construct such a focus in isolation from consideration of other important factors, notably the developments taking place in the technologies themselves and our growing understanding of just how wide some of the implications of the NIT might be for education; factors such as these will have an important bearing on the analysis offered here.

2. It is clear, from background papers to the OECD/CERI Project as well as from other sources, that the current effort being made by most Member countries to construct educational responses to the challenges of the NIT are little short of dramatic. The level of investment, in terms of both capital equipment and manpower, is remarkably high in many countries, and this at a time of general economic recession. Returns to the Project questionnaire provide clear evidence that this investment is the concrete reflection of a real concern to formulate a response to what is increasingly defined as a very large challenge indeed. Given that the current complex of activities dates largely from only the very late 70s (though earlier, mainframe-based, developments such as those of France and the United Kingdom were important) the word "dramatic" does appear to be entirely appropriate.

3. Nonetheless, it is necessary to recognise the complementary view that also emerges, again from both Project and other sources, namely that, despite the intense activity to which both human and material resources are so heavily commited, there remains a great deal more to be done in both the quantitative and the qualitative senses before we may begin to feel at all satisfied that the strategies emerging are adequate to take us and our pupils into the 21st century. The flavour of what has been achieved so far remains decidedly ad hoc (in the words of one United States paper, "at the local level, confusion appears to be the order of the day"). The relatively high levels of funding and of activity must not be allowed to disguise this fact.

4. That this should be so is scarcely surprising. The pace of technological development, as measured, for example, by the advances in the technical specifications of microcomputers available to schools in 1984, compared to those of 1980, has been extremely rapid. Keeping abreast of this pace of change is difficult, while the capital expenditure referred to above, in terms of hardware alone, is of a magnitude not easily inserted into educational budgets. Given, even more importantly, that arriving at an understanding of the educational potential of the NIT is a daunting task, it

is little wonder that national responses currently fall something short of fully co-ordinated policy.

5. What is currently encouraging is that priority areas for policy begin to be identifiable. The early emphasis, in many cases, was in fact upon the hardware and upon getting this into the schools as rapidly as possible. But Hamilton and Casserly (1983) point out, it was disturbing: "...that in some few cases the purchasing of equipment on a large scale had preceded the actual planning for what to do with it." But even when such short-sighted policies are adopted, however, it rapidly becomes clear that two other, very pressing, developmental needs emerge. One, which is extremely important, is the urgent need to acquire -- by whatever means -- software which actually has some educational value; a recurrent theme in country reports prepared for the OECD/CERI Project is the disappointing, and sometimes abysmal, quality of a great deal of the software available.

6. The second of the emerging priorities, and one with which this paper is centrally concerned, is for the training of teachers to use and develop the potential of the new technologies. Here there has been a dangerously circular dilemma. It is clear that the insertion of the NIT into educational use will -- or at least has the potential to -- bring about changes in the ways in which learning can be organised; that is to say, in the ways in which teachers function. We cannot predict fully the likely nature of these changes, partly because they are in any case notoriously complex, but also because there have not been sufficient teachers and, most importantly of all, makers of educational policy, with sufficient appreciation of the potential of the NIT to enable suitable forms of training to be established. It is a key problem. There is a very real sense in which it would matter relatively little if technological advance were to halt over night (it is of course unthinkable that it should) since there is sufficient implicit in existing technology to keep educationalists occupied for the rest of the century. But the full educational advance cannot and will not be made until a sounder understanding has been established of the new kinds of learning that become possible, of which of these are desirable, of their implications for the role and the functions of the teacher, and of their further implications for teacher education and training.

7. There is an important point implicit in the wording of the last paragraph: it resides in the deliberate emphasis upon the word "learning". For, while it is clear that the focus of this study is upon the teacher, teacher functions and teacher training, it is also essential to remember that the teacher is only a means to an end. The end is the education of the child. The danger of a focus upon the concept of the teacher is that it may engender the unquestioning assumption that, while minor modifications to the role may come about, the role itself will endure. This report is written in the belief that this is, in fact, the case, and that teachers will continue to be needed for the education of children for a very long time. But it has at the same time to be recognised that some of the potential uses claimed for the NIT do call in question the teacher role itself, while others postulate a change in teacher functions so extensive as to demand a major re-evaluation of that role. The emphasis on the centrality of the learning, rather than the teaching process, will help to maintain these possibilities in focus. It seems appropriate here to quote the words of the President of the French Republic: "Les Cahiers de l'Education Nationale" for December 1983 quotes M. Mitterrand as having said (at the colloque "Informatique et Enseignement"

which took place in Paris on 21st and 22nd November 1983): "...l'informatique n'est pas un domaine supplémentaire d'enseignement ; elle transforme la manière même d'acquérir les connaissances... " It is a salutary reminder.

8. Subject to this proviso, this study attempts to analyse the changes demanded by the NIT in teacher functions and in teacher training. Of necessity, it is prospective as well as descriptive. There is a widespread agreement that what has happened so far represents only the first steps and that a great deal more needs to be done; rather surprisingly, there appears to be an emergent consensus of opinion as to what the next steps might be. While such a consensus is by no means complete, it does allow for a responsible attempt at analysis to be made.

9. There does remain, however, one final and very important caveat to what follows. The remarkable level of financial investment, the greater part of it from public funds in all the countries concerned, has been mentioned already. There has been no precedent at all for such a large-scale insertion of capital technology into the school system. But what needs to be examined carefully is the possible unreality, of the present situation, since it is highly possible that those of us who attempt to project the development of the NIT in education, and who do so purely from an education standpoint, may be living in a fool's paradise.

10. Two interpretations are possible. There is the generous interpretation, which sees the investment as evidence of the overwhelming desire of governments (whether national or local) to see to it that education benefits as rapidly as possible the advent of an exciting new technology. There is the less generous view -- some would say cynical -- which sees what is happening as evidence merely of the strong motivation of nation states to safeguard their economic futures by investing in the technological training of their young. Certainly the popular and educational journalism of three of the countries involved has contained frequent references to the need to keep ahead or at least abreast of the Americans/the British/the French (depending on which of the three countries is the country of origin of the journal concerned); all three of the Western countries' literature refer to the need not to "fall behind the Japanese". If there is any truth in this cynical interpretation of the situation, then it is worth remarking that the financial bubble may burst. The intense interest of the NIT, from the point of view of the educationalist, is that they are ideally suited to supporting the teaching/learning processes. And it is already clear that there are yet further areas of development opening up which are of even greater interest for education: the growth of laser- (video-) disk encoding is a case in point. Such developments, however, are likely to be even more demanding upon resources than those known to us today, and it may well be the case that the level of investment demanded will go beyond what public funding will sustain, should a narrower focus be felt to be adequate for purposes of national economic advancement. There is no means of knowing whether such a scenario is realistic or not, but, given the present need to engage with an analysis which necessarily includes the prospective, it is salutary to bear in mind that the present climate of investment may just be that of a honeymoon period, and that there is no visible guarantee that funds will continue to be available to education on the scale of the present. The remainder of this report will be based on the tacit assumption that investment will in fact continue, but the making of this assumption should not obscure the extent of the act of political and economic will required.

Chapter I

CHANGES IN TEACHER FUNCTIONS: THE CURRENT PICTURE

11. A great deal of the educational development which has so far taken place in response to the emergence of the NIT has been ad hoc in nature. This is demonstrably the case where grassroots activity has been predominant, with individuals and small groups of teachers attempting for themselves to construct educational uses of the new phenomenon; it is also the case even where a lead has been taken at a higher level, say that of the municipality or a regional authority. That is to say, all such developments give the impression of being motivated more by an urgent need to initiate an activity (and, perhaps, to be seen to initiate an activity) than by a desire to produce a carefully thought-out strategy that would make proper use of the new resources and facilities coming into being. Nor do schemes at national levels offer a markedly different picture: both the Microelectronics Education Programme (MEP) in the United Kingdom and the national programme in France concentrate on partial approaches only to the total phenomenon. Given the rapidity and complexity of development of the phenomenon in question, this situation is scarcely surprising -- though not one which should be allowed to continue much longer. For these reasons, it is to a large extent easier and more interesting to construct a prospective picture of likely changes in teacher functions than it is necessarily to extrapolate from the evidence we have so far. Nonetheless, it is possible, even at this relatively early stage of development, to extract a number of learnings about likely changes in teacher functions from what has already happened in the growing use of the NIT in education. Although they originate in very different national contexts, the OECD/CERI background papers and reports are interesting in the extent to which they evidence already some broad similarities in the evolution of such functions, and it is upon these reports that many of the remarks which follow are based.

A. The Importance of Primary Education

12. In examining the implications of the NIT for teacher functions, however, we have to be clear as to the sense in which the word "teacher" is being used. The assumption will be made throughout this paper that the term "teacher" includes primary teachers, and, moreover, that the NIT have as much to offer at primary level as they do at any other level of our education systems.

13. This is a highly important point, and it would be idle to ignore that fact that it is to some extent controversial. It is clear from available evidence that, in a number of countries very little, or very little that stems from official policy, has been done to meet the challenge of the NIT at primary level. To go further: it appears to be the case that, in a number of countries, it has yet to be agreed whether, as a matter of principle, the NIT should be seen as having anything to offer at this level.

14. Here, one has to risk appearing dogmatic by stating categorically that this is a non-question. While the entry of the NIT into primary education in, for example, the United Kingdom and the United States is much more recent than at secondary level, more than enough has been achieved already to make it abundantly clear that the new technologies have a great deal to offer primary pupils and teachers.

15. It is not merely the much publicised claims of LOGO (Abelson and diSessa, 1981; Bossuet, 1982; Papert, 1980; Schwartz, 1981) which substantiate this point, though, to anyone who has worked on LOGO with primary children it is evident that this language alone has a major contribution to make to the learning of the young child. But work at the primary level, certainly in United Kingdom schools, extends far beyond LOGO alone. Extensive data base programs, word processing, adventure games and simulations -- as well as the ubiquitous drill-and-practice -- have all been tried and tested at primary level. It is against this background that it becomes possible to state categorically the role of the NIT at this level. It is a role which may be denied by policy decision, though it is difficult to see how primary schools anywhere can withstand the onslaught of the home computer. Indeed, for the primary school not to take heed of the "educational" software now finding its way onto the home computer market would be shortsighted in the extreme. Very clear evidence of the potential of the NIT at primary level emerges from not only the works cited, the authors of which are all of university level, though working with young children, but also from an extremely preceptive Headmistress of Pentland Priary School, Ms. Liddell, to the United Kingdom Background Report. In less specific detail, but drawing upon evidence from across the United States of America, reports prepared by Professor Nolan Estes, of the University of Texas at Austin and by Professors Robert D. Hess and Irene T. Miura, of Stanford University point clearly to the emergence of the microcomputer as an educational force to be reckoned with at primary level. The evidence is overwhelming: the questions concerning the insertion of the NIT into primary education are not "whether", but "how quickly?" and "how effectively?"

16. It is on these grounds that this report, in examining the implications of the NIT for the functions and the training of the generality of teachers, takes as axiomatic that its concern is as much with teacher at the primary level as with their secondary colleagues. Indeed, one can go further: if the new technologies are to make the major contribution to educational development of which they are capable, it seems essential that correct strategies be implemented from the outset. Such an implementation, in other words, must commence at the very earliest stages of learning.

B. The Emergence of the NIT Co-ordinator

17. When we look for concrete evidence of the new functions demanded of teachers, some very useful data is to be found in the emergence of what is essentially a new category of teacher, namely the person designated in a given school as the co-ordinator for insertion of the new technologies. Whether this be part of a national strategy, as in the cae of teachers trained under the French "long course" scheme, a condition of provision of hardware, as under the United Kingdom Department of Industry scheme, or a more spontaneous response to an identified need appearing in all countries, it is clear that there is a growing demand for some teachers (at least one in every school developing the use of NIT) to:

-- Be identified as "resource persons", knowledgeable about the NIT, to whom their colleagues can turn for informal advice;

-- Take a lead, more formally, in school-based in-service training;

-- Be responsible for the management of NIT hard- and software resources and of technical support staff;

-- Contribute to software design and development;

-- Advise headteachers and school managements on acquisitions policy as well as on longer-term education development.

18. The phenomenon is interesting, and widespread. It is referred to in a French background paper by M. Jean Valérien, dealing with developments in the Académie of Rennes; the "animateur" function is a recognised part of the strategy of dissemination in France. A case-study contributed by Mr. T.D. Pike, Deputy Headmaster of a boys school in Orpington, to the United Kingdom background report, on the other hand, shows how this kind of role has often developed from the enthusiasm of an individual. Not that all United Kingdom development is pragmatic; a contribution by Mr. W.R. Broderick to the same report shows how one English Local Authority planned for the creation of such a role. The United States reports of Estes and of Hess and Miura also refer to the important contribution made by this new category of teacher.

19. There is here, identifiably, a new cluster of teacher functions to be discharged, and a great many teachers, in diverse settings, are carrying an extremely heavy burden in an attempt to respond to the challenge. One may add that it is questionable whether the whole phenomenon of NIT in education would have left its launching pad had it not been for the quite extraordinary enthusiasm which the field generates in many teachers. The demands are remarkably onerous. Notoriously, the NIT phenomenon is not static; it is about as dynamic as it could conceivably be. Consequently, the "NIT co-ordinator" in a school must not only discharge all the functions identified above, but must also keep abreast of constant technological development. This does not necessarily require active participation in research in the scientific sense. But at the very least, merely to remain well informed requires, in the United Kingdom, perusal of at least some of the many technical journals which have proliferated over the past few years; personal experience suggests that perhaps eight monthly journals are obligatory

reading, in addition to a number of new books, the rate of publication of which far outstrips that in any of the traditional school subject areas. Yet a further dimension of learning is added by the machines themselves, since familiarisation with the intricacies of a microcomputer such as the Acorn/BBC machine which is much in evidence in United Kingdom schools is in itself a demanding process. Moreover, the microcomputers themselves are not the only machines to be mastered. Peripherals such as disk storage systems, printers, Videotext and Teletext adapters and network interfaces each have their own operating systems, all of which have to be learned. Finally, the software itself represents an additionaal learning burden, especially as it becomes more ambitious; to demonstrate software to colleagues, or to teach to students, requires considerable prior time spent in study and evaluation. Comparisons with other, more traditional and static, subject areas are simply not realistic.

20. This is not a problem which is likely to go away. The preparatory training which is undergone by some teachers -- for example, that supplied by the French long courses -- does not obviate the necessity for the co-ordinator-teacher to continue with a constant self-updating. At present, there does not seem to be any evidence of allowance being made for this need. A case-study from one of the Scottish regions (by Mr. C.F. MacLean, Adviser in Educational Computing for Lothian) specifically draws attention to the need to allow teachers discharging these new clusters of functions to have time for the necessary personal development. As matters stand, the demands of computer clubs, peer training and the writing of programs for both pupil use and the use of colleagues (for the motivation to demonstrate to others the values of the new technologies is high) leave time at a premium.

21. But there is in fact a further point to be made, which relates specifically to the needs of the new "NIT-co-ordinator" teachers but which is also of very considerable significance at whatever point, or at whatever level, any teacher comes into contact with the new technologies. It is a point upon which a special emphasis will be placed in this report; namely, that the learning demands imposed upon teachers are not merely of the kind identified above -- centered, that is, upon learning about the technology. Onerous though this area is, there is an even greater learning challenge to be faced which is not technological but essentially pedagogical in nature.

22. The point emerges if we re-examine the list offered above, of the new functions imposed upon the co-ordinator-teachers. Peer training, for example, calls for a high degree of andragogical understanding, to say nothing of associated skills in interpersonal relations and sheer old-fashioned diplomacy; this latter is much called upon in situations, all too frequently encountered, where colleagues (possibly of considerable seniority) are hostile to or suspicious of the new technologies. Resentment of the comparatively lavish resourcing currently available to the NIT in schools and colleges is often another complicating factor; the case study by T.D. Pike refers to this.

23. Similarly, while it is clear that the design of good software calls for an understanding of what computers generally, and a particular machine specifically, is capable of doing, what is also called very much into question is the teacher's ability to construct sound learning experiences. This clearly is a pedagogical, not a technological, skill, and the fact that the teaching/learning medium is new makes all the greater demand upon pedagogical analysis and design.

24. The need for development in these areas is very great. Indeed, if the new technologies are not be, at least misunderstood, and at worst abused in educational terms, it is essential that attention be given to training in these areas. A heavy investment in the further professional development of these teachers is called for.

C. Implications for the Generality of Teachers

25. The relatively clearly discernible set of functions which are emerging for the new NIT teacher-co-ordinators provide a useful introductory basis on which to attempt a similar analysis of functions for the generality of teachers across all subject areas. As we do so, the picture inevitably becomes less clear-cut. It is necessary to recognise, for example, that there are many individual teachers, even in those countries relatively advanced in their uses of the NIT, who remain unaffected by the new developments. The reasons can be diverse: in many cases, there exists suspicion or downright hostility, the basis of which may be anything from personal antipathy to technology per se to a distrust of educational consequences of the NIT. Often, this distrust reaches back to experience of programmed learning experiments, which is one of the more unfortunate associations conjured up by the vision of computer technology in education. Pike, in the United Kingdom paper referred to, mentions this distrust; it is a common phenomenon. For many other teachers, the delay in adjustment may stem from mechanistic factors as simple as non-availability of appropriate software in a given curriculum area.

26. But this is only the negative side of the coin. Equally, there are a great many teachers who are neither teachers of informatics nor responsible for the NIT on an institutional basis who have been working with the new technologies for a sufficient length of time for a preliminary analysis of functions to be made. At this stage, the analysis must be relatively simplistic, and it is certainly open to extensive modification as we improve our shared understanding of what the NIT imply for education. Nonetheless, the analysis can be made; here, it will serve also as a basis for the more prospective view of the next section and for an examination, finally, of the implications for teacher education.

27. In the analytical researches undertaken by the Information Technology and Teacher Education group of the Association for Teacher Education in Europe, it has proved very useful to take as a starting focus the progression from machine-related factors to factors related to the (educational) environment (van Weert 1984). The same starting point is adopted here, though the analysis offered is differently expressed. This orientation to the question of teacher functions produces a three-stage pattern. This will be dealt with in outline first.

28. First, there are functions related to the technology as machine. There are broadly two functions involved here; they are:

-- Basic machine competence; and

-- Competence in management of the hardware resource.

While these might appear at first sight to be relatively low-level functions (as, essentially, they are) they nonetheless represent a formidable addition to the range of competencies hitherto acquired by teachers.

29. Second, there are functions which relate to software -- in other words, to available applications of the NIT. For the present, these may be represented simply as:

-- Competence in the range of applications offered by the NIT.

Nonetheless, this is in itself a very wide field, and the extent to which it broadens the range of teacher functions is, as we shall see, very considerable.

30. Third, there are the classroom-based functions, related to the translation of the potential of the technologies into pedagogic use. This, also, is an extensive and complex field, but for the purposes of outline only it may be identified as:

-- Competence in the pedagogic use of applications of the NIT.

31. Before we proceed to a closer examination of these three broad areas of teacher function, there are one or two general comments which need to be made. One is that the key area, at present, is the second: acquisition of an understanding of what the technologies are capable of doing. Another is that the first two, related the hardware itself, tend all too easily to become disproportionately important. There are reasons why this should be so. Using a microcomputer -- considered purely as machine -- is, after all, considerably more complex than using, say, a slide projector or a tape-recorder in the classroom; the fact of pupil use is in itself sufficient to present the teacher with a host of unforeseen problems. But the reasoning goes deeper. There was a phase in the evolution of the automobile when to be a driver one needed also to be a mechanic (or be able to employ a driver-mechanic); the same was true of the early aviators. Similarly, there has been a period in which the use of the computer has been very much the province of those able to master it as a machine -- in other words, to program. This is reflected in the contents of many syllabuses dealing with what is termed, in the United Kingdom, Computer Studies, and also in the assumptions which many teachers bring with them to in-service training courses. One of the most welcome of recent trends has been a discernible move away from this emphasis on the teacher as programmer, in the direction of teacher as (informed) user. If this shift is to be maintained, it becomes important to see that all teachers understand the range of applications of which the technology is capable. It is competence in this area which stands at the interface between the technology and its educational use; once this is more broadly established than it is at present we shall be better placed to proceed with pedagogical exploration.

32. We may now look in more detail at each of the functions identified above:

a) Basic machine competence

33. The teacher has long been someone who handles, as an aid to the teaching/learning processes, a range of technology which encompasses

recorders, film projectors and slide projectors. Teachers of sciences normally draw upon a wider range, but the majority of teachers operate with a very limited range of technology.

34. Using the microcomputer takes the teacher into a more complex area, and one which is rendered so by the interactive nature of the technology. That is to say, basic machine competence requires not only the ability to switch a machine on and off, or even to load and save programs. The run-of-the-mill techniques of entering data, retrieving crashes, making backup copies, dealing with disk faults, obtaining printouts and screen dumps are all necessary to the teacher who wishes to be no more than a competent client, one who uses the resources of the new technologies without necessarily becoming involved in any developmental work. The addition to the teacher's range of competencies must not be underestimated. There are far too many points at which the technology can "play up", and thereby ruin a carefully prepared lesson (this can and does happen to all of us, however competent we may be) for the matter to be taken lightly -- especially, as we have said, given the interactive nature of the medium. It is often difficult enough for the teacher to deal with his or her own errors, but it is necessary also to be able to cope with child-induced errors. One answer to the problem (though at best partial) would be a considerable increase in provision of ancilliary staff (technicians) competent in computer hardware, but in present economic climates it might be unwise to bank on this being available in the short term. The implication is that there exists a range of basic machine competencies which will be needed of all teacher users of the new technologies.

b) Competence in management of the hardware resource

35. Teachers express concern about another extension of their competencies which is also at a mechanistic level; the extent to which this is a problem depends on the amount of hardware available. The point is that, while fully-equipped computer classrooms are now coming more widely into being, they are still not commonplace. Hamilton and Casserly, for example, in a study prepared for the United States background report, refer to an analysis of the hardware situation in schools associated with the Council of the Great City Schools (and hence not claimed to be wholly representative of the United States). This indicates an average ratio, at secondary level, of one computer (micro or terminal) to every 186 pupils, though ratios ranged from 40:1 to 473:1. At primary level, the average was 863:1, in the range 97:1 to 4 000:1 (!). Clearly, reducing such ratios is a long-term and expensive task: a very crude notional calculation for the United Kingdom, based on projected expenditure for the City of Manchester over a five-year period, and aimed at putting twelve microcomputers into every City secondary school, would cost approximately £85 million. The implications for teachers are obvious, and the statistics illustrate perfectly why teachers who habitually use computers frequently find themselves carrying delicate and fragile equipment around school buildings and elsewhere. There exists, clearly, a major problem of resource management, and there enters a new teacher task: that of working out how best to utilise a form of learning which is heavily machine-based when the number of machines available is not adequate. In an ideal world, the problem would not exist, but it does, and represents a major additional burden upon the teacher; the burden is not the less for being unnecessary.

c) Competence in the range of NIT applications

36. While the new functions identified under (a) and (b) above are certainly demanding, they are nonetheless, as has been made clear, essentially machine-related tasks. But what is true for business users of the new technologies is true also for education, namely that the hardware is of less intrinsic importance than the software which it runs. Thus it is only when we move away from machine-related issues and begin to examine the range of applications offered by software that we can truly begin to explore the educational potential of the NIT.

37. The full range of this potential is only beginning to emerge. Early developments were characterised by two emphases. One, upon uses in the field of mathematics, is understandable given the developmental history of the computer, but misleading insofar as it gives only a very limited picture of what the new technologies have to offer. This problem is doubly confounded by the fact that mathematics, sadly, is a subject area in which many teachers as well as pupils profess limitations and even antipathy. While there are strong, and bi-directional, links between mathematics and computer usage, there are, as we shall see, many more possibilities for educational development than in the field of mathematics alone. The second emphasis, upon relatively simple drill-and-practice programs, is even more unfortunate. It is also wryly ironic, in that the unprecendented but still limited powers of the microcomputer have tempted many teacher enthusiasts into producing such programs, when experts who have worked for many years in the field of Artificial Intelligence, using mainframe computers, realise just how far research and development have yet to go before we can produce programs which begin to match the sophistication which the teacher brings to the instructional function (O'Shea and Self, 1983). We return to the question of Artificial Intelligence later.

38. The emerging picture of educational uses of the NIT is much broader. To a considerable extent, it draws upon developments in the field of business applications, where the incentives for progress have been high. And because the picture is a broad one, it is essential at this point that we introduce a second level of analysis, which will offer a perspective on this central question. It is possible to identify the following (not necessarily complete) range of applications.

Drill and practice

Although it is unfortunate that applications of this type have tended to be more in evidence than is ideally desirable, it would be pointless to overlook the contribution which drill and practice routines can offer. They offer a considerable potential for reinforcement of learning, and an opportunity for some pupils to progress to challenges at an appropriate level without necessarily waiting for the teacher to intervene. What is perhaps even more useful is to see drill and practice in a developmental context: with the technology available in sufficient quantity in any one school, and with appropriate software also available, drill and practice can lead easily into computer monitoring of performance and thence into fully-fledged computer-aided student profiling and management of learning. This possibility raises, of course, a number of educational questions -- for example, there is the danger of monitoring student performance solely in terms of assessments

which can in fact be made by compters; Section d) below will take up pedagogic issues of this nature;

Electronic blackboard

The technologies offer the teacher an electronic "blackboard" of a kind not hitherto available, and which represents an important addition to the teacher's repertoire. Its significance as a teaching aid is two-fold. First, it is dynamic, in that it can change rapidly, in time, as a schematic representation of information; this is a quality which it posesses to a greater degree by far than, say, the slide or transparency projectors. Secondly, it is interactive with the input of either teacher or pupil, and this creates a flexibility which is simply not accessible, or only in the crudest form, via existing technologies. This, clearly , is an important facility. Nor should it be seen as relating to work with numeric data only: the word-processing software with which this paper is being prepared, for example can also be used as an electronic blackboard (as can a beautiful and inexpensive primary wordprocessor which recently became available in the United Kingdom).

Games

Computer games, of the kinds available in arcades and for home computers, have been much criticised for the hold which they exert on young minds. Yet, as M. Jean Valérien points out in his study of NIT developments in the Britanny region of France, the electronic microworld of the game is an important part of the adolescent's reality, and cognisance must be taken of the fact. Games succeed or fail on the challenge which they offer to the player's skills, and there is here a potential which very much calls out to be used in education. This is beginning to happen, and already adventure games exist on the educational market which offer a strong stimulus to both the imagination (some of the most interesting are aimed at primary level) and the development of problem-solving skills. It is likely that current developments in linking video imagery to the computer (see Chapter III below) will further increase the attraction and potential of games.

Simulations

While the distinction between games and simulations is of course important -- games belong in the world of fiction and fantasy, or else are "play" presentations of problems, while simulations model a part of the real world -- it is clear that they offer a similar attraction. The computer-based simulation offers a potential for examining a very wide range of situations which it would not normally be possible to examine in the classroom (for reasons of size, complexity or risk element) and it does so in a way which is, once again, dynamic and interactive. Here again, the marriage of video imagery with computer programs and computer-based data banks must inevitably contribute to the impact of simulations, and it is possible that this will prove to be one of the most important growth areas in the development of computer-based learning.

The representation of knowledge

Here also there exists a very great potential indeed for the educational application of information technology. Indeed, it is at this point that the very close links between the NIT as a phenomenon, on the one hand, and on the other the process of educating, become most evident. Both are concerned with facilitating our ability to transmute raw data into knowledge -- i.e. data which has been structured, organised, above all understood by the user -- and which can be recalled, and if necessary re-structured and re-interpreted to meet fresh demands. (In at least one European language -- albeit a minority language, Welsh -- the term "Information Technology" is rendered as "Knowledge Technology".) If we are to deal succinctly with what is a large and complex topic, it may be helpful again to refer to uses of the NIT in the field of business. There, it has become the accepted target for "integrated" software that it shall provide within the one shell facilities for data processing, for text processing, for numeric calculation (spreadsheet) and for the graphic representation of number and quantity. Each of these separately offers a direct aid to the teacher and to the learner; integrated into the one package, as in existing business software, they will offer yet another dynamic resource for the teaching/learning process. (It is correct to say "will" rather than "would" offer, since it is already possible to use business oriented software for educational purposes; this remark is based upon experience of using, for example, business data base and spreadsheet software in the training of primary teachers.)

The formal construction of knowledge

One of the most prolonged debates in computer-based education has concerned the practice of teaching pupils the skills of programming. Much of this debate has centered around the alleged unsuitability, for educational purposes, of the language most used in the English speaking world, namely BASIC. Certainly it is true that BASIC is a conceptually untidy language, and it is also highly debatable whether all pupils and all teachers need to be skilled at programming. However, one has to recognise also that languages whch have appeared more recently, of which the best-known are LOGO and PROLOG, put into the child's hands what Seymour Papert likes to call "powerful tools" with which to engage in the formal exploration and construction of knowledge. This is an important concept, which needs careful attention (Papert, 1980).

39. Clearly, it would be possible to enter into a great deal more detail in respect of each and every one of the applications of the new technologies listed in the last paragraph. Equally, it would be possible to add one or two more categories to the list as it stands. But the point is not to establish a definitive categorisation; in such a rapidly evolving area, such an attempt would be shortlived. What is more important is to establish that there does exist a wide range of applications of the NIT, such as the range described here, and that these applications all bear, in their different ways, upon the possibilities open to the teacher in the classroom.

40. If these possibilities are to be realised, however, then teachers must be more than simply knowledgeable about the range of applications available. The new technologies further demand that teachers have a grasp of their pedagogic implications.

d) Competence in the pedagogic use of the NIT

41. We saw under Section (c) above that there exists a wide range of possible applications of the NIT in the classroom. Their existence raises the question of their implications for, and their impact upon, the ways in which we teach and in which our pupils learn.

42. This impact varies according to the nature of the application in question. For example, if we are thinking of "electronic blackboard" applications, then, though these may make new demands upon the teacher-user, they need involve no re-think of the pedagogy in operation; the gain may be considerable, in respect of, for example, the dynamic quality which may be given to illustration, and pupils' learning may be much facilitated, without there being any fundamental change in the teaching/learning styles involved. But from there on, it is difficult to conceive of the new technology's being used without pedagogical practice being called into question.

43. The point emerges even when elementary drill-and-practice routines are being used. When the child is operating a program of this kind at the computer keyboard, the learning (or learning-reinforcement) situation is quite different from that which operates ordinarily in the classroom. To begin with, the pupil's situation is private, so that mistakes made do not risk public comment (or ridicule) from either fellow-pupils or teacher. Secondly, there need be no element of competition. In any classroom where questions are asked publicly, there are, inevitably, those pupils who are prompt and eager with their answers, and those who are more reluctant and/or less able. It is a situation where, with the best will in the world, it is difficult to prevent many children from acquiring negative self-images vis-a-vis their contemporaries, with a feed-back effect upon further learning which is well-known. In the private dialogue with the computer, however, the pupil need not be hurried by any implicit competitiveness: it simply does not exist. In its stead, there emerges a challenge to the pupil as an individual, a challenge, moreover, which good programming can render appropriate to the pupil's level of attainment. Given, additionally, the capacity of this kind of CAL to monitor the pupil's progress and to log for the teacher the number of errors made, and the levels at which they occurred, it becomes clear that there is now available to the teacher an additional teaching strategy which has not hitherto existed. The deployment of this resource (quite apart from the mechanics of sharing it across the class) becomes a pedagogic question of considerable interest (Bossuet, 1982).

44. What is being invoked, of course, is an extension of our present potential for the individualisation of learning. To say this is not to suggest that individualisation is an over-riding goal; there are many cases where it is inappropriate. But it is equally, and importantly, true that there are many occasions where it is supportive to tailor the learning experience as closely as possible to the developmental needs of the individual, and it is already clear that the computer, not to mention other aspects of the NIT, has a great deal to offer in this respect.

45. But once we begin to explore the pedagogical implications of NIT applications, we find ourselves moving into increasingly interesting levels of enquiry. In the last two paragraphs we have identified one or two of the positive features of the pupil-computer interaction -- the relative privacy of the situation, the removal of competitiveness. But these are not the only

features of the situation. Whether the software involved be drill, game or simulation whether pupils work at the keyboard individually or in groups (both styles, of course, are appropriate at different times) it is clear that working with computer-based programs offer children a learning experience which is different from others normally available in the classroom. Many factors come into play: the fact that the computer does not appear impatient, that it can respond instantly and accurately to whatever is input to it, that it appears objective and neutral in its responses (all sorts of subjective remarks, of course, can be written into programs, but that is a different matters) and that, perhaps, the mere fact of its being a machine -- all of these, and other factors as well, make up a learning transaction which is somehow different from that to which we are accustomed in the classroom. Precisely what the nature of that transaction is, it is too early to say, and it is an area where a considerable amount of psycho-pedagogical research is called for (O'Shea and Self 1983). What is clear is that the new element which it introduces calls for an extension of the teacher's pedagogical armoury.

46. The point need not be laboured, but it is important to point out that it increases in significance the more we consider the range of applications available. The introduction of data bases, spreadsheets and word-processing, for example, are all of the utmost importance for the functions discharged by the teacher. What is critical here is the extraordinarily close match between the process of acquiring learning, on the one hand, and the nature of the new technologies on the other. To acquire learning is to develop the ability to retain a mass of raw information, and to structure and shape it in such a way that it becomes useful knowledge or understanding that can be called upon, applied to different situations and conveyed to others as necessary. And this, of course, is precisely what the new technology has been created to do: to capture data, process, structure, retain, recall and transmit. The conceptual overlap is remarkable, and it would seem essential that all teachers acquire an understanding of the ways in which computer applications such as data bases and wordprocessing offer their pupils learning tools of a new, and extremely important, kind.

37. There is a similar point to be made about the computing languages increasingly becoming available to education. Within computer education circles, there is an on-going and fierce debate over what many see as the unsuitability of the language most commonly used for education in the English-speaking world, namely BASIC. It is certainly true that there appears little intrinsic worth in teaching BASIC outside of the Computer Studies syllabus. Other high-level languages, notably PASCAL and COMAL (Atherton, 1982) offer intellectual challenges which have more intrinsic worth, but their place still lies within the subject area. However, the same cannot be said of LOGO, which is best known for its Turtle Graphics capacity (though this is only a subset of a full LOGO) and for its accessibility to even very young children (Bossuet, 1982; Papert, 1980; Watt, 1980, 1983) or of the more recent PROLOG, through which lower-secondary children can create and interrogate quite complex data-structures (Ennals, 1983; Clark & McCabe, 1984). Languages such as these move outside the computer studies area -- though they are based on the soundest of computing practices -- and begin to be relevant to a wider range of subject areas, further extending the pedagogic repertoire available to the teacher. Whereas the applications referred to in the last paragraph are invaluable in the organising of knowledge, these languages make an equally important contribution to the

building of concepts. PROLOG, for example, or its microcomputer version micro-PROLOG, offers insights into logical relation setting which is as much the province of the teacher of the mother tongue or of History or Geography as of Computer Studies.

48. The catalogue of possibilities presented here is by no means exhaustive, and there can be no doubt that others will emerge. But the prospective analysis is the subject of the next chapter; what is important to emphasize here is that everything which has been said has been based on developments, at the technology/software end, which have taken place already.

49. This last is a sobering thought, for if all the hardware and software developments on which the foregoing paragraphs are based are already with us, it is far from being the case that we have learned to make full educational use of them. All that we can say at present is that it has become possible to reach the stage at which a paper such as this becomes possible -- that is to say, one which offers, with reasonable confidence, an analysis of the issues at stake. It would be sensible to assume, in all probability, that it would take at least another 20 years to learn to exploit even these developments to the full; given the inherent conservatism of the education system (though not of teachers) 20 years is perhaps a wildly optimistic hope.

50. But at least the analysis is possible. It becomes possible, on present knowledge alone, to see how teacher functions are already open to modification. And from this analysis one point emerges, the importance of which cannot be over-emphasized. It is that the changes which we can identify in the teacher function are not themselves intrinsically technological in character: they are, as we have seen in the case of the NIT co-ordinators, pedagogical in nature.

51. If we take a broader view, this ceases to be surprising. While the invention of the steam piston engine was important as a technological advance, it was less important as technology per se than as the invention which made possible the railway engine, which in turn made possible the movement of coal, raw material and goods, the transport of human beings (Lenin, for example, to the Finland Station) and the production and distribution of cheap national daily papers. The technology has been important only for what it makes possible -- in the case of the steam piston engine, massive social, economic and political change.

52. When this perspective is applied to the NIT in education, the full complexity of the situation faced by educators in the last decades of the twentieth century becomes, if possible, even more apparent, and it is at this point that it becomes important to concentrate on issues which are capable of being confronted in practical terms. For there are, in fact, two major considerations implicit in the wider perspective. We may take first the larger of the two, which is in fact analogous with what has just been said about the steam engine. It would be irresponsible of educational planning to ignore the predictions currently being made (Toffler, 1980; Stonier, 1983 -- to select but two out of many texts) about the impact of the new technologies on the social and economic structures of life in the 21st century. If these predictions are only in part fulfilled -- which seems inevitable -- then the societal context in which education is situated will have been altered to such an extent that our systems of education will have themselves to change.

53. But this, as we have said, is the larger of the two considerations subsumed under the broad perspective on technological development, and as such it more properly relates to the prospective analysis of the next chapter. The more specific consideration is in no sense prospective: it is the point made above, that the implications for education of the technology as we already know it are extensive to a degree in the re-think they demand of the functions of teachers, and that such a re-think needs to focus far less on the technology per se than upon the pedagogical developments which it makes possible -- which, indeed, it makes inevitable. While no-one (surely?) would argue that all teachers need to learn Assembler, it is already difficult to conceive that coming generations of teachers will be able to function without an understanding of the nature of relational data bases and ability to incorporate the use of such resources into their classroom practice. This is a pedagogical issue of the first importance.

54. It would be foolish to claim that the analyses offered in this Chapter -- whether the basic three part analysis of competencies or the more detailed analyses offered under the second and third of these heads -- are definitive. Indeed, given the rapidly evolving nature of the subject-matter, and the rather less rapid evolution of our understanding of it, the contrary is to be hoped. The important point is that the analysis can at least be made, that it can be made on the basis of what we know already of the NIT and their impact upon education, and that it leads us already to an understanding of at least the likely pattern of change in teacher functions. On this basis, we can begin to look at the steps needed to set in motion a better-planned transition to the necessary pedagogical changes, through teacher training especially. This will be the focus of the last Chapter of the present paper; before coming to the question of teacher training, however, we need also to incorporate into the overall picture the more prospective analysis of the next chapter. While this, too, is firmly rooted in reality, in that it is based on technological developments which either have taken place already or are confidently predictable on the basis of the existing, it does nonetheless open up issues which have not yet been touched upon, in any real sense, in educational planning. Such issues are a necessary complement to those identified in the paragraphs above.

Chapter II

CHANGES IN TEACHER FUNCTION: THE PROSPECTIVE ANALYSIS

55. In the light of our expressed belief that it will take twenty years at least to extract full pedagogical capital out of the technological resources at present available to us, it may seem surperfluous to engage also with "what-if" analysis. Future predictions are notoriously difficult, and we should also take into account the fact that some of the existing teacher mistrust of the new information technologies relates to predictions that teachers, like other classes of employee, will be rendered redundant by the new technologies. Such a mistrust, we may add, is not confined to teachers along: there is a wide-spread repugnance, amongst parents and many others, for the notion that Artificial Intelligence machines of the future might be entrusted with what has always been the human relationship of teacher and pupil.

56. This particular bogey is clearly germane to the debate, and we shall return to it. However, a prospective analysis of likely developments of the NIT in education does not have to extend as far as the possible teaching computers of the next century. It is not even necessary to base such an analysis on any technological "what-if". We have seen already that there is a great deal to be done to exploit the new technologies which have already entered educational practice; there is even more to be done to respond to those technological developments which have already taken place but which have not yet affected education. (This last point is relative, since some of the developments in question are on a continuum from other already referred to, but there are, nonetheless, important distinctions to be drawn.) In the remainder of this report we shall be concerned only with technological advances which have already taken place or with relatively limited extrapolations from these into the near future; we are emphatically not concerned with predictions based on science fiction or fantasy.

A. Five Areas of Technological Development

57. It will be helpful, first, merely to identify a few areas where technological development has a particular relevance to education:

i) We are already witnessing a rapid increase in the processing power of the microprocessors used in computers of the kind found in

schools and homes. The first microcomputers to become widely available in schools were eight-bit machines; 32-bit processors are already in machines being marketed, with all the increases in processing power and internal memory that 32-bits imply (Mateosian 1984). The processing power of the microcomputers which will be available cheaply in, say, four years' time (1988) will bear no comparison to the power available to the machines produced four years ago (1981).

ii) Equally significant are the advances constantly being made in backing storage; indeed, the rapid reduction in the cost of memory per byte is regarded as one of the most important developments in microcomputing technology. Two areas are of interest here: one is laser disk technology (Duke, 1983; Rothchild, 1983) while the other is the techniques being developed for dense encoding of electronic data (Johnson, 1983). Both methods make for a vast increase in the amount of information which can be easily stored and made cheaply transportable.

iii) The growth in storage capacity is closely linked to another advance and indeed makes it possible; this is the capacity to create multi-media resources. The OECD/CERI paper prepared by Professors Le Corre and Schwartz is especially valuable for its comments in this area (CERI/NT/83.07), and we note their prediction that laser disk storage capacities will increase tenfold within the decade. Since these disks can already encode data of different types (Le Corre and Schwartz quote, for example, five million pages of text or one hour of live video) the potential for multi-media storage is extremely high. This development is of extreme interest for the creation of educational resources.

iv) Developments in software are also of interest. While the evidence is that attainment on a microcomputer of the integrated, multi-function software which business normally expects of a mainframe or a minicomputer is still elusive, rapid strides continue to be made and are supported by the emergence of the 32-bit processors and increased memory (Brown, 1983; Callegari and O'Connor, 1983; Chang, 1983). The emulation of such packages at the level of the school will be of considerable significance. Other software developments of high interest include a recent breed of programs in the United Kingdom and the United States which are marketed as "thought-processors", i.e. electronic notepads which, through the use of tree structures, can identify correspondences between different sections of, for example, notes used in the preparation of research reports. The educational potential of both these developments is evident.

v) Fifth, account needs to be taken of the high state of development reached in communications technology. Hitherto, the focus of thinking about the NIT in education has tended to be exclusively the microcomputer itself. This is a point heavily emphasised in the OECD paper CERI/NT/83.11. Only now, with the advent of telesoftware (still in a rudimentary state) and early steps towards the educational use of Videotext are we beginning to

explore this potential. Both fibre optic cable relay systems at local levels and developments such as direct broadcasting by satellite at international level open up new dimensions in the delivery system possible for educational materials (Maddison, 1983).

58. We have here identified five fields in which development is proceeding apace, where it is not necessary to engage in long-term speculation, and where there are clear implications for educational use. We shall turn in a moment to analysis of some such possible uses, and attempt to see what a scenario for the development of teacher functions over the next decade might be. First, however, there is one other area of which mention must be made.

B. The Contribution of Artificial Intelligence Research

59. While the field of Artificial Intelligence is one much mistrusted, and probably misunderstood, from the outside by teachers and others, it is important to note that it is also the field in which the most serious research into the NIT/education interaction has been going on the longest. Indeed, if we pay due attention to the "new" in NIT as relating essentially to the era of the microprocessor, then we have to recognise that AI research in education predates the new technologies, being based as it has been on university mainframe computers. It could well be the view of the researcher in AI that the easy accessibility of microcomputing has been a hindrance, rather than a help to progress, since it has given a seemingly seductive computing power into the hands of amateurs who are not qualified to use it and who do not realise that, marvellous invention though it is, the microcomputer as we have so far known it does not have, in fact, the kind of power required on which to create interactive expert systems. Certainly, many of the so-called CAL programs which exist at present are crude, miniscule and trivial compared with programs developed on mainframes over a decade ago (O'Shea and Self, 1983).

60. The question which popularly arises in question with AI in education, one upon which we have already touched, is that of the possibility of constructing expert tutor systems, capable of dialoguing with students and, in effect, of supplying the teaching function. If this proves to be possible, then clearly there are major repercussions for the world of education, since the role of the human teacher is itself called into question.

61. A full treatment of this issue would require a greater space than is available here, as well as a more expert writer. But the consensus currently appears to be that, while it is in theory possible to construct such systems, in practice the sophistication of programming required remains elusive. O'Shea and Self, in the work cited, and Boden (1977) point to the very long way that still has to be travelled in the direction of the expert tutor system, despite the achievements of, for example, the PLATO system in the United States. Thus the spectre of the teaching force being replaced by computer terminals is perhaps remote -- so far as AI is concerned; there is a greater threat to the teacher, to which we shall return.

62. But the production of a computer-based tutor system is not of course the only goal of AI research. It is far more profitable, for the immediate

future, to look to AI for continuing insights into the ways in which computers can be made to model learning processes, and for the psychological insights which such research can bring. It is important to recall, for example, that the widely-acclaimed LOGO, to which reference has been made more than once in this report, is itself the product of research into Artificial Intelligence.

63. Equally interesting to education is the work currently being done by Artificial Intelligence research in respect of "expert systems": that is to say, extended data bases into which are fed the knowledge and the rules called upon by human experts in addressing decision making in given areas, the system being programmed to extract "inferential" conclusions from the data supplied. The best known such system already operative is in the field of medicine. While expert systems are still at a relatively early stage of development, they nonetheless exist, they are on a clear continuum from ordinary data bases, and are a means of organising and representing knowledge which has to be of interest to education.

64. It is in areas such as these, rather than in respect of any immediate threat from robot "teachers", that Artificial Intelligence promises to make a highly important contribution to the impact of the NIT upon the teacher function. What could well be strengthened is the interface between the world of research and the world of the classroom and of teacher training -- the latter perhaps especially. Excellent models for such interaction exist -- as for example between the MIT LOGO Project and schools and at the University of Edinburgh, and it would seem essential that the interaction be extended.

C. The Pedagogic Implications

65. For the present, it is possible to construct the necessary prospective analysis of further changes in teacher functions by examining more closely the technological developments identified in section A of this chapter (para. 57). A number of inferences can be drawn: there are perhaps four of these.

Resources

66. The first is that there exist already the technical means for organising learning resources in ways which have not hitherto been possible. Le Corre and Schwartz draw important attention to this possibility in their paper, and this report echoes their identification of "interactive multi-media computerised learning environments" as a key to progress. Where one might wish to draw somewhat different conclusions is over their prediction of the kind of use which might be made of such resources. There does not appear to be any particular reason why the multi-media packages envisaged should be seen as instructional in function -- indeed, the reverse. To attempt to use such technologies for instruction will be to encounter afresh all the difficulties referred to above in respect of tutoring systems. Instead, it would seem more appropriate, at an early stage of development especially, to see multi-media technologies as not being electronic only, and also to see them, above all, as resources. Whatever data, sound, still or video imagery is encoded on an education-oriented video disk could and should be linked to other media at

least in the first instance -- certainly until the NIT offer clear advantages over the portability and readability of worksheets and books. The essential, it would seem, in the development of these new packages, is that the overall function of the teacher be enhanced and not diminished. The specific new task created for the teacher will be that of mastering and using this enormous potential, and this will be a major challenge. But if teachers are involved with the task of authoring the new resources, two benefits will accrue. First, use of the NIT will be able to draw upon the limitless experience which the teaching profession has accumulated over many generations. Secondly, the teaching force itself will be engaging with the NIT in a positive manner which will serve as a further focus for professional development. [The case for seeing the new technologies as encompassing a number of existing media, and allowing them to be used far more powerfully and creatively than at present, is passionately argued by Maddison (1983)]. For the teaching profession not to be engaged with the production of the new resources could well be disastrous, as we shall see later.

Learning

67. A second inference to be drawn is more challenging. Already we have seen, in the case of LOGO at primary level, that the NIT offer new ways of learning. And there is evidence from the LOGO experience that many teachers find it difficult to adjust to the extent to which LOGO gives the child a considerable element of control over its learning progress. The same is true of the use of PROLOG and indeed of any situation in which the child has use of a powerful computational tool, particularly when the pupil's access to that tool is outside of the control of the teacher -- in, for example, the home. Increases in microcomputer power and in access to large data banks and to privatised learning resources will further accelerate this trend. Thus the new function for the teacher is two-fold: that of adapting to new ways of learning and to the fact of no longer being in control of the learning process. (This, of course, is not really a new phenomenon, since what we know about informal learning tells us that teacher control of the "real" learning process is a myth. What the NIT do is to make the fact more difficult to ignore.)

Knowledge

68. A third point, closely allied to the last but separate from it, is that advances in the NIT already call in question our existing definitions of knowledge. Laser-encoded disks can carry the equivalent of five million pages of text. But, protected as they are by plastic film, laser disks are far less sensitive than are current floppies or Winchesters; they can, for example, be stacked and "played", juke-box fashion ... ten laser disks -- even one laser disk -- will carry far more information than any one individual will need to access in a lifetime. Similarly, the current advances in storage offer portability. Memory cards (plastic cards encoded with data either elecronically or by laser) are already on the market (Johnson, 1983; Mills, 1984; Rothchild, 1983) and mean that the individual could carry about, in a small wallet, all the information that is likely, for example, to be required during the working week. This is to say that knowledge per se carries a far lower premium. What is more important to develop, and what represents a major new extension to the teaching function, is the ability to

access knowledge and to use it when found. As we saw in Chapter II, the growth of data banks already calls for teaching responses; what the new encoding techniques do is to exaggerate the demand even further. This is perhaps one of the most exciting challenges for education in the context of the new technologies. What is also interesting is that it demonstrates how the NIT can actually have a liberalising influence on education, in the sense that its use leads to an emphasis on the development of understanding and on the use of knowledge, at the expense of rote learning.

Communications

69. The final prospective inference to be drawn from existing technological developments is in many ways the most open-ended and the most contentious. We have noted already that there is more to the new technologies than computers alone, and that, for example, the communications aspects have important implications for education. In effect, existing communications capabilities are sufficient to raise a question mark -- in purely technological terms -- against the existence of school as we know it. Distance learning, after all, is far from new in a number of countries, and the NIT technically offer a fascinating opportunity to go beyond anything yet achieved in the delivery of learning. This is certainly likely to happen for learners in remote communities, in hospitals or who are house-bound. The question arises over the extent to which such developments should be allowed to affect what we now regard as compulsory schooling. School itself is a delivery system for learning, and it is at least debatable that the new technologies offer a more efficient delivery service -- and very likely one that is more economical. Le Corre and Schwartz see this ("... education will become less dependent on the centralised school setting."). Stonier (1983) argues interestingly that:

> "The major shift in technology... involves the emergence of the electronic home-based education capability using the television screen and the computer terminal as its base, tied via telephone, airwaves or local cable television to the local education authorities, a second tie-in to national and international computer networks and finally a tie-in to the global library archives."

It is difficult to avoid the conclusion that there is some substance for this prediction (Gwyn 1982), however difficult it may also be to see Stonier's prediction as spelling the death of school. School has evolved over a very long period of time, and fulfills a wide range of functions. These include, very importantly, the socialising function and, at a lower level, the custodial. The vision of children below the age of ten receiving their education via their own home terminal or that of a neighbour is, essentially, the middle-class vision of the pre-school playgroup which may well not correspond to the realities of many parents' working lives. Nonetheless, the NIT Place a very firm question mark against the nature of school as we know it.

70. Nonetheless, the potential of the NIT for the delivery of education is not one to be dismissed lightly. If the totality of present technologies, coupled with those developments which are identifiably imminent, do present the opportunity, as we have seen, to produce new multi-media teaching resources, we have also to recognise that the processes of production will be expensive. Collaborative, studio-based teams are likely to be required. Such a development must be viewed positively if it means an end to the small-scale,

educationally inept software with which we are currently encumbered, but there is the negative effect that the production process becomes remote from the teacher; this is the threat to which we alluded earlier. Teachers do not normally write their own resource materials -- i.e. books -- at present, but a book-based technology still allows the classroom teacher a very great deal of control over its use. The same is not true of existing educational television; typically, the teacher does not interrupt a television broadcast, and not only for the obvious reason that the broadcast is a one-off: it is also important that television as a medium engages the watcher's attention on a greater scale than does the book. The same will be true of NIT-based resources generally. They are likely to exert a much more powerful hold on pupils' attention than does the book or, by extension, the teacher. Unless teachers have the possibility to be involved in the preparation of the new resources, there is a real danger that they will see the NIT as intruding, powerfully, in their traditional relationship with their pupils. Much will depend, as we have seen, on the extent to which the new software is resource-oriented, and the extent to which it sets out to "teach". The former, we have argued, is to be preferred, especially as a first stage of development.

71. The impact, for the functions of the teacher, of the possible development of the NIT as delivery system for education is intriguingly difficult to predict. The vision propounded by Stonier, presumably, sees no place for the schoolteacher as such, at least not until the secondary stage is reached. But if we believe that the social pressures for the preservation of the school will persist, then a very interesting scenario opens up, in which the teacher has access, through the NIT, to an extensive storehouse of resources, far easier of integrated use than are the educational film and television programs of today -- and far more under the teacher's control, if the prescriptive approach is avoided. The availability of such resources, with all that they imply for the individualisation of learning, will reinforce the influence of data bases and related developments in the liberalising process. It becomes possible to envisage a school in which far more time can be devoted to the growth of interpersonal skills and to creative and artistic endeavour than to learning as narrowly defined. That such a scenario might result from purely technological development would be ironic, but it is a scenario well within the capacities of the technology as it exists to deliver to the schools of the 1990s.

72. Consideration of issues such as these move us increasingly into the realms of the speculative. It is important, however, that we recognise just what is speculative and what is not about the prospective analysis offered here. There are three areas to be taken into consideration.

73. The first of the three may be disposed of briefly, since the point has been made already in this analysis. It is that the technological picture painted here is in no sense speculative. As we have remarked, Chapter II of this paper refers only to developments to which the educational system is already responding, however inadequately, while Chapter III is based only on developments which have taken place or are imminent, but which have not found their way into education. The second and third areas to be considered, however, are speculative in nature.

74. What has emerged from the analysis of Chapter II, and is equally evident from that of Chapter III, is that the responses which the NIT demand

of the teacher role are pedagogic, rather than technical, in their nature. But we have offered already the opinion that the technological developments we have witnessed already would keep us occupied in devising educational strategies to utilise them to the full, to at least the turn of the century. And it is here that a note of caution becomes essential. The potential changes to which we are referring are considerable. In some cases, they call for a radical re-appraisal of our attitudes to learning, to our concept of knowledge and of what it is to be an educated person. In other cases, especially those highlighted in the present chapter, they call in question our thinking about the relationship between teacher and taught, about the organisation of the school and about its function in society. Such questions are not lightweight. We have no means of predicting whether our educational structures, or the social structures of which they form an integral part, have the innate flexibility to enable them to adapt to the many possibilities offered up by the NIT. Most specifically, it seems reasonable to ask whether we have yet an adequate understanding of the processes of teaching and learning to enable us to exploit the new potential to the full. If the change from Industrial to post-Industrial society is anything like as extensive as the change from Agrarian Society to Industrial, and if, as we have to expect, it proves to be concentrated into a relatively very brief time span, then there is reason to fear that our pedagogical wit may be found wanting. The question is, it must be emphasized, speculative, but to ignore it would be irresponsible.

75. The third area to be considered, and the second which we must identify as speculative, has been identified tentatively already, in Chapter I of this paper. It concerns the political will to support educational development relative to the NIT. Such support, clearly, is and will continue to be expensive for the foreseeable future. It seems reasonable to anticipate that, the more such investment becomes investment in education for its own sake, unrelated to economic growth, and the more it is seen to call in question some of the social functionalism that is built into our education systems, the less will be its attractiveness as an area for heavy investment by governments. This is an hypothesis only, and one which, as an educator, one would wish to see disproved. However, in so far as the question is legitimate, then so far must further development remain, ultimately, also open to speculation.

76. We are here, very deliberately, limiting discussion of the kind of social changes which we may be facing, and taking the school itself as the point of focus. But it would be unwise to ignore altogether the extent of possible changes predicted by many as we move from Industrial to post-Industrial society. Such predictions are in themselves manifold; they embrace possible changes in the work-ethic, in the distribution of time between work and leisure, and in the nature of work available, challenges to the privacy of the individual in the face of unprecedented means of control, and questions of the policing that will be required in the "leisured" society. Such questions, clearly, are of the utmost importance for the future of society as we know it, as are the more immediately threatening issues of survival in the nuclear age. The outcome of each and every one of these questions has, clearly, implications, for education systems, for schools, for teachers and for their pupils. That they have not been raised in detail or considered at length in this paper is not an indication that they are considered to be of little or no interest. On the contrary: they are of the greatest moment. The problem which they present is that they suggest degrees of change so great as to be, radically, changes in kind from what is at

present known. A paper such as this can be written only from the tacit assumption that educational development can take place, and will take place, under relatively controlled conditions in which there will be world enough and time for plans to be made, and decisions taken, in a responsible and thoughtful manner. Whether this will, in fact, prove to be the case is in itself a matter for very considerable speculation.

Chapter III

THE IMPLICATIONS FOR TEACHER TRAINING

77. In the previous two chapters we have identified a range of changes in teacher functions posited by the NIT, and have defined these in terms of the new approaches to teaching and learning which the new technologies open up. It is clear that the introduction of these new functions -- whether according to the categories identified here or any other analysis -- calls for a major input from teacher training. It is particularly encouraging to note the seemingly universal acceptance of this principle. The background report on France prepared by M. Jean Valérien relates in detail the teacher training provision made in one French Académie in respect of the new technologies, but the basic principle is widely shared.

78. It is also clear that the effort required is called for at both the levels of pre- and in-service teacher training. This said, all the evidence in background reports from the United States, France and the United Kingdom points to an emphasis on the in-service activity as a priority. This is entirely understandable, since it is an accepted fact that new thinking can be injected into teaching more quickly via this route -- where courses can be mounted at relatively short notice and can be brief and intensive -- than via the necessarily longer pre-service route which produces, after all, the junior members of the profession. Nonetheless, there is evidence also of considerable development taking place at pre-service level; this is found also in M. Valérien's report, in, for example, an extremely interesting contribution to the United Kingdom report by Mr. R. Hartley, Director of the Computer-based Learning Unit of the University of Leeds, and in other contributions.

79. What is evident, however, from a reading of these and other papers, and from discussions within the Information Technology Group of the Association for Teacher Education in Europe, as well as from extensive personal experience of planning NIT courses at both pre- and in-service levels in a large teacher education institution, is that there are major problems to be tackled in this area if we are to have any hope of mounting, via teacher education, a worthwhile response to the challenges faced. This chapter will attempt to analyse these problems and to offer a perspective upon possible action.

80. A first problem concerns the analysis itself. The situation which it examines is essentially circular, with no easy and obvious point of entry to the range of problems to be identified. What seems most appropriate, therefore, is to sketch in, relatively briefly, the entire range of issues before attempting to impose upon it a sense of priorities.

A. INSET - logistics

81. We have seen, in Chapters II and III, that the new technologies carry implications for all subject areas across the curriculum, and that this is true at both primary and secondary levels. Given that the number of teachers at these levels who can reasonably claim to have received undergraduate training in Informatics (even if this were necessarily the best preparation for using the NIT in teaching, which is by no means self-evident) is negligible, what this means is that we face the need to train, as rapidly as possible, the entirety of the teaching profession to use the new technologies. Given the rapid evolution of the whole area, it is scarcely any exaggeration to say that the whole profession needs, by some means or another, to be placed in semi-permanent re-training. There are many reasons why it would be wildly impracticable to think in these terms: a lack of trained trainers, economic constraints, a lack of sufficiently clear agreement on the directions to be followed. The logistics of such an exercise would be overwhelming. And yet this is, in fact, fundamentally the task facing the various agencies of teacher in-service training, and its seriousness should not be ignored.

82. So far, the most visible scheme to have emerged at national level is that of France, and it is clear to anyone who has studied the French programme that there is a great deal to be learned from the scheme. The MEP scheme in the United Kingdom also places a heavy emphasis on teacher training (vide the United Kingdom national report by former HM Inspector Maurice Edmondson) but, in the nature of the United Kingdom decentralised system, is not in a position itself to offer INSET schemes on the same scale.

B. Pre-service: Structures and Resources

83. As we have said there exists a greater possibility of flexible responses to new developments at in-service level than at pre-service. In the latter area, courses are of longer duration and often subject to formal processes of approval and control which are less easy to change. Frequently also, pre-service courses for intending teachers are intensive in their pressure upon the students' programmes; Maurice Edmondson remarks on the difficulty of inserting new areas of learning into already crowded curricula. (This is a problem which mirrors the debate in France over the insertion, into the secondary curriculum, of Informatics as a discipline; if this is to happen, something else has to give way.) Personal experience has demonstrated how difficult it can be to insert into the very crowded one-year course of post-graduate teacher training in the United Kingdom anything approaching a sufficient initiation into the new technologies for all students -- and this in an institution where colleagues are strongly supportive and hardware resources available. What is equally interesting, in the same context of personal experience, is the marked increase in student demand, over some three or four years, for some element of computer literacy to be introduced into their courses.

84. Hardware resources, of course, are not necessarily available to all teacher training institutions, and there are resourcing problems to be faced on a large scale in many countries. Nor is this a question of hardware alone; it is a commonplace of business use of the NIT to look first for software appropriate to needs, and to worry about the hardware later. The same situations cannot yet be said to apply in education, since the hardware is considerably more in evidence than is software which will truly stand up to educational scrutiny. Nonetheless, this too is beginning to emerge, and it places upon the budgets of teacher education institutions a heavy burden of purchasing in a period when this particular sector of the education system, in a number of countries, is particularly subject to cut-back.

85. But the major resource problem is the human one. The proportion of teacher trainers with Information Technology as their "subject" is even lower than for teachers at secondary level. In those countries which allow professional movement laterally across disciplines, this has been the solution which has emerged -- very often, of course, it has been Mathematicians who have provided the input. (The author of this report is unrepentant of having moved into the teaching of Information Technology from the totally "opposite" end of the curriculum spectrum, namely English Literature.) In countries where the teaching of a discipline is relatively strictly linked to possession of an academic qualification -- Germany is a case in point -- a severe problem exists. Nor can the problem of human resources be ignored in a country traditionally as flexible in its attitudes to subject qualifications as the United Kingdom, since the flexibility in the system is balanced out by what amounts to, effectively, a standstill on recruitment into teacher training for almost a decade. The need to re-train the trainers, if they are in fact to be able to train their own subject-area students, is acute.

C. Research and Development

86. One of the problems facing teacher education is that of knowing which direction to follow in the provision made for students at both pre- and in-service levels. In a highly dynamic area such as the NIT, those involved in teacher training find themselves of necesssity attempting to keep abreast of a range of developments. And the breadth of this range must not be underestimated; it encompasses the latest in educational software, which needs to be examined and evaluated, trends in the field of business applications, from which the educational world has so much to learn, new languages which appear to offer valuable directions for teaching (COMAL, LOGO, micro-PROLOG...) new applications packages (word processing, spreadsheet...), indications of policy directions and also the latest information from the world of academic research (Artificial Intelligence, expert systems...). The list is daunting, to say the least. What it calls for is an involvement on two fronts, namely those of professional development and of research. These, of course, are not necessarily the same, and both are important.

87. There is a considerable body of evidence, much of it subjective and uncorroborated but substantial nonetheless, which suggests that circumstances inhibit an adequate participation by teacher educators in research in this, or in many cases any, area. The circumstances can be varied. In some education systems, research as such is not seen as the province of teacher training;

elsewhere -- and this is subjective testimony but borne out by colleagues from a number of countries -- the heavy demand for training in respect of information technologies and education leaves those able to offer the training required with very little time indeed for research. This problem in fact extends beyond research; it is common to hear colleagues who train in the uses of the new technologies complain that their commitment to the professional development of others leaves little or no time for their own. We have touched upon this problem already in examining (Chapter II) the role of, and the demands upon, the new "NIT co-ordinators" in the schools (C.F. MacLean, Lothian Case Study for United Kingdom Background Report). It is a relatively new phenomenon, as of course is the whole area, but it appears to be already a serious problem for teacher education.

D. The Need for Policy Guidelines

88. A final problem area concerns the need for clear policy guidelines and for the direction which pre- and in-service training should take. There is an obvious distinction to be drawn here between the situation in decentralised countries such as the United Kingdom and the United States, on the one hand, and a centralised country such as France on the other. The distinction is especially illuminating given the amount of development work done in each of these three countries; this is covered in the background reports on these countries (Valérien, Edmondson, Estes and Hess and Miura). It is clear from the report prepared by M. Valérien that the teacher training initiative for the NIT in France benefits from fitting into an overall plan which includes both curriculum materials development and a strategy for creating a multiplier effect. Personal contact with colleagues who work within the French system suggest that this has generated a sense of direction which could well be echoed elsewhere. It appears also to be a strength of the French programme that professionals who are closely involved in the teacher re-training scheme (upon which an important emphasis has been placed) are closely consulted about, and contribute to, the development of policy.

89. The picture in the decentralised countries is very different. The United States reports reveal a wide range of initiatives being taken in the various States, without there being any necessary uniformity of approach in any one State. Leadership groups emerge by a natural process, but again to a local, not a State or national, pattern: a City administration here, a teacher training centre there, elsewhere a research centre such as that of the MIT LOGO Group, a Parent Association, a group of teachers or even an individual. Any one of these bodies may have, in a given setting, a decisive influence on development. The picture is very similar in the United Kingdom. Much has been made, quite rightly, of the important role played by the MEP, which has been in many ways a remarkable development in a country with as strong a tradition of decentralisation as the United Kingdom. But the role of MEP is essentially that of resource co-ordination, of stimulus and of launching of curriculum development activity, coupled with an element of teacher training limited mainly to short sensibilisation courses. In no sense is MEP intended as a vehicle for the development of a national policy. As a consequence, the initiatives which are of long-term importance in respect of teacher training for the NIT are those of the teacher training institutions themselves and of the Local Education Authorities, through their Advisory and Teachers' Centre

activities. (It may indeed prove to have been the case that the concentration of effort at national level on the MEP has distracted both attention and resources away from the more permanent agencies of training.)

90. Nothing in life, of course, is as simple as the two preceding paragraphs might seem to suggest. It is not a straightforward case of the centralised system scoring heavily over the dencentralised: far from it. The very real strengths of the decentralised systems lie in their ability to let a thousand flowers bloom. As a consequence, the sheer diversity of the developments which have taken place in the United States and the United Kingdom have led to a great deal being learned about the range of contributions which the NIT might make across the curriculum and at all levels, while the centralised approach is at the same time more organised and thorough, but also more limited in the range of what it does.

91. At the heart of the dilemma there stands the teacher trainer, whose contribution, all are agreed, is of the highest importance but who risks, on the one hand, working to a pattern which is, relatively speaking -- the qualification is highly important -- "handed down", or on the other, working in a policy vacuum and having to carry, probably with a small group of colleagues, a heavy responsibility for the direction taken by the teacher training (and consequently by the teachers who are trained). If a choice has to be made between the two poles of centralised and decentralised approaches, it is certainly tempting to say that, given the complexity of the whole NIT phenomenon, and given also the extent of investment in time, money and human resources called for, the former has a number of advantages. It is here worth quoting a remark made in the United Kingdom report by Maurice Edmondson, until recently a member of Her Majesty's Inspectorate in the highly decentralised British system: "The blending of initial training with a programme of continuous refreshment and up-dating by means of in-service courses in desirable and national guidelines on how best this might be designed and arranged would be helpful."

E. Teacher Training and the NIT: the Prospect for Success

92. In the foregoing paragraphs we have identified some of the major problems faced by teacher education as it attempts to measure up to the challenges of the new technologies. The problems, as we have said, are to some extent circular. Without clear policy guidelines, for example, there is no clarity as to the kind of training to be given to teachers or to teacher trainers. But the lack of trained expertise in the educational use of the NIT is itself a contributing factor to uncertainty about policy directions. The teaching undertaken by trainers is often not as well supported by involvement in research and development as it might be; this is partly because trainers in this field are so much in demand. And so forth: there is a real danger that the contribution expected of teacher education will be crippled from birth, if not stillborn.

93. If teacher education is to make its essential contribution -- as all within the training sector would undoubtedly wish it to do -- then it would seem that a number of facts need to be faced. These are partly, and importantly, to do with resourcing, and overall to do with the creation of a climate for development.

94. The resourcing required falls under three main headings:

i) The institutions which train teachers will need a considerable investment in physical resources. These will include both hardware (which will carry with it, for the foreseeable future, a need for renewal over, possibly, a three- or five-year cycle to keep provision up-to-date) and software. The importance of this latter, especially in countries where educational software, and software with a relevance to education, is likely to be produced by the private sector, is considerable;

ii) It will be necessary to invest heavily in the retraining of the trainers themselves to enable them to introduce the NIT into their work across the curriculum. Nor can this be seen as a "one off" process. The pace of change is likely to make a semi-permanent system for up-dating the NIT skills of the teacher trainers essential. (It should be added that the term "trainer" here refers to those who train the generality of teachers. It will be equally important to up-date the skills of those who train the trainers -- i.e. those who are versed in the new technologies will also need refresher experience).

iii) It is highly unlikely, in many cases, that the training programmes required can be inserted into existing workloads, which are already very high in this area. It seems inevitable that providing bodies will be faced with the need to recruit new and additional staff if adequate responses are to be mounted.

There would appear to be a strong case, at policy-making levels for a review of requirements in these areas.

95. Clearly, the further strengthening of resources in these ways would do a great deal to enable teacher education to meet the NIT challenges. What are additionally needed are the two elements already identified: a more effective link with research and development, and, in some countries, clearer policy lines for development.

96. Each of these, of course, feeds from the other, and it is worth examining more closely the ways in which research and development could aid the better formulation of policy guidelines. The key point here would seem to be the interpretation put upon the concept of research, and it appears essential that this be not construed simply in terms of scientific research alone.

97. Scientific research has an extremely important contribution to make; we have referred already to developments in Artificial Intelligence and in storage technologies. It is essential that developments in the field of teacher education be able to take cognisance of these and similar advances. Additionally, however, we have stressed throughout this report the importance, in educational terms, of the applications of the NIT, and have drawn attention also to their wider implications. Thus the construction of a strategy for the training of teachers has to take into account developments which cover a very wide range: these include, for example, the use of public data banks as resources for learning, enhanced uses of the broadcasting media (vide Maddison, 1983) for the delivery of learning packages, examination of new

patterns of work and leisure, questions of individual privacy -- and so forth. Responses to such a wide range of phenomena, which embrace technological development, pedagogical application and social implication, are surely too complex to be decided by any one sector alone. What happens in education as a consequence of these new developments -- in short, what teachers in the future will do, what functions they will fulfill -- cannot be determined solely on the grounds of technological/scientific trends or by fiat of political leaders -- and certainly not solely by teacher trainers having to make up their own minds about what to teach.

98. Two steps would appear to be essential. The first step would be the creation of settings in which careful, controlled experiment could take place. Such settings would need to be large enough to sustain a viable range of uses of the new technologies, and also large enough to involve a representative cross-section of interests in guiding development. Equally, they would need not to be so large as to involve entire education systems, or to create undue problems of co-ordination. The precise nature of the seetting is not critical. It could equally be a medium-sized city or a rural area with a more widely distributed population. What matters is that, within our various education systems we establish in such selected settings a commitment to development across the entire spectrum of educational services and levels, from pre-Primary to teacher education and incorporating the education of children of all abilities and in all settings (the hospital or home as well as the schools). While the development activity would be led by the responsible educational authority -- since its goal would be to map out a total and integrated set of answers to the insertion of the NIT into education -- it would draw also upon the expertise of local commerce and industry, of the NIT industry itself, of media and of publishers, of trade unions, parents, teachers, cultural and social interests (including minorities) and, of course, teachers. National authorities and examinations boards would need to be involved also. If a dialogue could be established on such a wholistic basis -- taking a community-wide look at a phenomenon which affects the whole community -- and properly resourced, then there might be a chance that we should arrive at wholistic solutions. Specifically, we might arrive at a view of the new functions demanded of the teacher, and consequently of the task required of teacher training and retraining, which was based on more than the circumscribed and entirely ad hoc set of actions which we are perpetrating at the moment.

99. The second step would be a logical -- surely? -- extension of the first. Given the broad similarities of socio-economic organisation which override the cultural differences between most of the developed nations, it is reasonable to see the educational problems posed by the new technologies as being, again broadly, the same from country to country; the technology itself transcends national boundaries. Yet anyone involved in examining the NIT/education phenomenon at the level of Europe only, let alone the wider membership of OECD, has to be conscious of how little is done, in real terms, to share development costs in what is, by normal education budget standards, an enormously costly phenomenon. It is not difficult to envisage the benefits that could flow, in terms of experience gained, insights shared and, also, concrete joint actions on, for example, software, if it were possible to establish a network of the kind of developmental settings outlined in the previous paragraph, perhaps no more than two or three in any one country. It would not be necessary for each to follow a shared line of development -- indeed, the reverse. Since the future pattern of educational use and

provision in the wake of the NIT cannot be predicted, it would be immensely valuable to have a number of linked but separate and diverse activities proceeding in parallel but sharing from each other's learnings. Strategies of this kind, admittedly, go beyond what has hitherto been attempted: we are talking of curriculum development on a very large scale indeed. But the point is precisely that it is development on this large scale that the new technologies may demand. And they are, after all, technologies of information: it requires little imagination to see how the new, enhanced communications technologies could be put to serve a network of the kind outlined.

100. Whatever strategies we adopt to face up to the inevitabilities of development, two things, finally, stand out. One is that we cannot much longer evade a thorough-going assessment of the deep changes which the technologies of information call forth in the function of the teaching profession. Whether that re-assessment follows the pattern outlined here or not, is immaterial. All that this paper attempts to do is to suggest that a framework for analysis has become possible and that we can no longer justify the ad hoc. The second point which stands out is that, whatever set of changes in teacher functions finally emerges as dominant in the wake of the NIT, the response of teacher education will be critical, inevitably, in the process of helping the teaching profession to adapt to these changes. A continuing and serious investment in the resourcing of the capacity of teacher education to make the required contribution seems to be, even more than ever, crucial to development.

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